Circular No. 675
April 1944 • Washington, D. C.
UNITED STATES DEPARTMENT OF AGRICULTURE

Control of the Mexican Bean Beetle in Irrigated Districts in the West

By R. L. WALLIS, *associate entomologist, Division of Truck Crop and Garden Insect Investigations, Bureau of Entomology and Plant Quarantine, Agricultural Research Administration* [1]

CONTENTS

INTRODUCTION

The Mexican bean beetle (*Epilachna varivestis* Muls.),[2] a native North American insect, is the worst insect enemy of beans in the infested areas of the West. The damage done by this pest has been so great in some years that if control measures had not been applied, the crop would have been completely destroyed. It is difficult to estimate the annual monetary loss to the growers of dry beans, but it is evident that without control measures commercial bean growing, in many sections, would have to be abandoned.

During the years from 1923 to 1934, inclusive,[3] experimental work on control of the Mexican bean beetle on the dry bean crop under dry-land conditions was carried out by the Bureau of Entomology and Plant Quarantine at Estancia, N. Mex. The present circular is a report of like investigations on irrigated land in Colorado during the years 1935 to 1938, inclusive.

The Pinto bean (*Phaseolus vulgaris* L.), the main variety grown in the infested areas, was used in these studies. The majority of the tests reported on in this circular were performed with sprays. To provide helpful information on the use of dust mixtures against the Mexican

---

[1] Acknowledgments are due Neale F. Howard for valuable advice throughout the course of these experiments, and to R. A. Fisher, W. C. Schick, and others for assistance in applying control measures and obtaining field data.

[2] Formerly referred to as *Epilachna corrupta* Muls.; order Coleoptera, family Coccinellidae.

[3] DOUGLASS, J. R. HABITS, LIFE HISTORY, AND CONTROL OF THE MEXICAN BEAN BEETLE IN NEW MEXICO. U. S. Dept. Agr. Tech. Bul. 376, 46 pp., illus. 1933.

bean beetle on the dry bean crop, and on the use of sprays and dusts on garden or canning beans, short discussions are also included in this circular dealing with these subjects, based on results obtained by workers of this Bureau in the East.

NATURE OF THE INJURY

The Mexican bean beetle and its larva have mouth parts adapted for chewing. The adults, or beetles, often cut through the upper surface of the leaves, although they usually feed, as do the larvae, on the underside, leaving only the larger veins, and the result is a lace-like network. Leaves that are completely skeletonized dry up and drop from the plant, while the efficiency of other leaves is reduced in proportion to the degree of injury.

Feeding is mainly on the leaves, but the pods and even the stems will be attacked and destroyed when the food supply becomes scarce. When the infestation is severe, the plants will be completely defoliated (fig. 1).

Figure 1.—Garden beans destroyed by the Mexican bean beetle. Uncontrolled infestations on garden plots are a source of infestation for adjacent commercial plantings.

As the overwintered beetles prefer the larger plants, probably for protection from the hot sun, they can be found moving from one field to another early in the season looking for the most suitable food supply. The early.planted fields, therefore, receive the heaviest infestations. Late planted fields may almost entirely escape injury because, after the early planted beans become larger, there is less tendency for the beetles to move about.

The eggs are deposited in clusters on the underside of the leaves. The larvae, after hatching, remain for a few days grouped together on one leaf, but as they become older they move about, although remaining in the vicinity of the plant where the egg mass was deposited.

CONTROL EXPERIMENTS

METHODS

This experimental work for the control of the Mexican bean beetle was conducted on a large-field-plot basis in cooperation with commercial growers of the Grand Valley of Colorado, on whose lands the usual cultural practices were followed. The plots were laid out and marked as they were treated. Although they each covered about 1 acre, the size varied slightly, depending on the area covered by one tankful (125 gallons) of spray material. It was difficult always to cover the same area with a spray tankful of material because of the variations in the speed of the team and the size of the nozzle apertures, and because of the extent of turning involved at the ends of the rows. Each treatment was replicated on four plots selected at random each season.

All the insecticides used were of commercial manufacture. They were weighed before spraying operations were begun, in quantities to make 125 gallons of spray mixture. The rotenone-bearing compounds were analyzed each year by the Division of Insecticide Investigations, Bureau of Entomology and Plant Quarantine, the rotenone content being used as a basis for making the proper dilutions. The rotenone content of these materials during the seasons that the investigations were conducted is shown in table 1.

TABLE 1.—*Rotenone content of the derris and cube used for making spray materials*

Source of rotenone	1935	1936	1937	1938
	Percent	*Percent*	*Percent*	*Percent*
Derris	4.5	5.1	3.5	6.2
Cube	3.6	4.8	4.7	5.4

Six pounds of hydrated lime was used with each pound of calcium arsenate to prevent foliage injury. One or more check plots, depending on the arrangement of the field, were provided for each replicate.

All the materials were applied with a 4-row power sprayer (fig. 2) at 350 pounds' pressure, except in 1935, when, because of the unavailability of such equipment, a traction sprayer giving only 100 pounds' pressure was used. It is believed that a pressure of 100 pounds is too low to give the best results, and that 350 pounds is higher than is really necessary. A pressure of at least 150 pounds should be used, however, in order to blow the leaves about and assure thorough penetration of the spray into the foliage.

Three nozzles were used on each row. The lower nozzles on each side were directed upward at an angle of 45° so as to spray the underside of the leaves from both sides of the row (fig. 3). These nozzles are turned at slightly different angles so that the spray does not exactly meet in the center of the row. The third nozzle was directed downward from above the center of the row. The lower nozzles were just high enough above the ground to prevent them from dragging when small beans were being sprayed. On larger beans they were raised slightly. Sections of hose in the vertical outlet pipes prevented the pipes from being broken on uneven ground.

The time for making the first application each season was determined from data on the time of emergence of overwintered beetles, obtained from hibernation-cage studies. The first sprays were applied when emergence was complete, and before egg deposition by these overwintered beetles had progressed very far. This usually placed the first application during the first 2 weeks in July. When the initial infestation is less than five overwintered beetles per 50 feet of row, the first spray may be delayed a few days with the expectation that one application will be sufficient to protect the crop throughout the season. Records of beetle populations have shown, however, that an initial infestation of five or more beetles per 50 feet of row may lead to early damage and that therefore such infestations should be treated promptly.

The time of planting will determine, to a certain extent, the size of the initial infestation, since beetles emerging from hibernation will select large, early planted beans instead of the late planted crop. If the beans are planted later, the time of the first application may be delayed. In 1935 the first application was made on July 11 to 17, followed by a second on July 25 to 30, except on one of the four replicates, where the infestation was not heavy enough to warrant a second application. In 1936 the first application was made on July 2 to 15, followed by a second on July 18 to August 7. The wide spread in dates that season was caused by the fact that the infestation on one replicate was slow in developing because of late planting. In 1937 the first application was made on July 14 to 19, and the beetles were so few that a second application was not needed. In 1938 the first application was made on July 6 to 8, and on one replicate a second was made on July 27.

FIGURE 2.—Power sprayer used in experiments on Mexican bean beetle control. Power equipment is essential for obtaining the 150 or more pounds' pressure necessary for effective control.

The results of the experiments were determined by counts of the insects and by yield records.

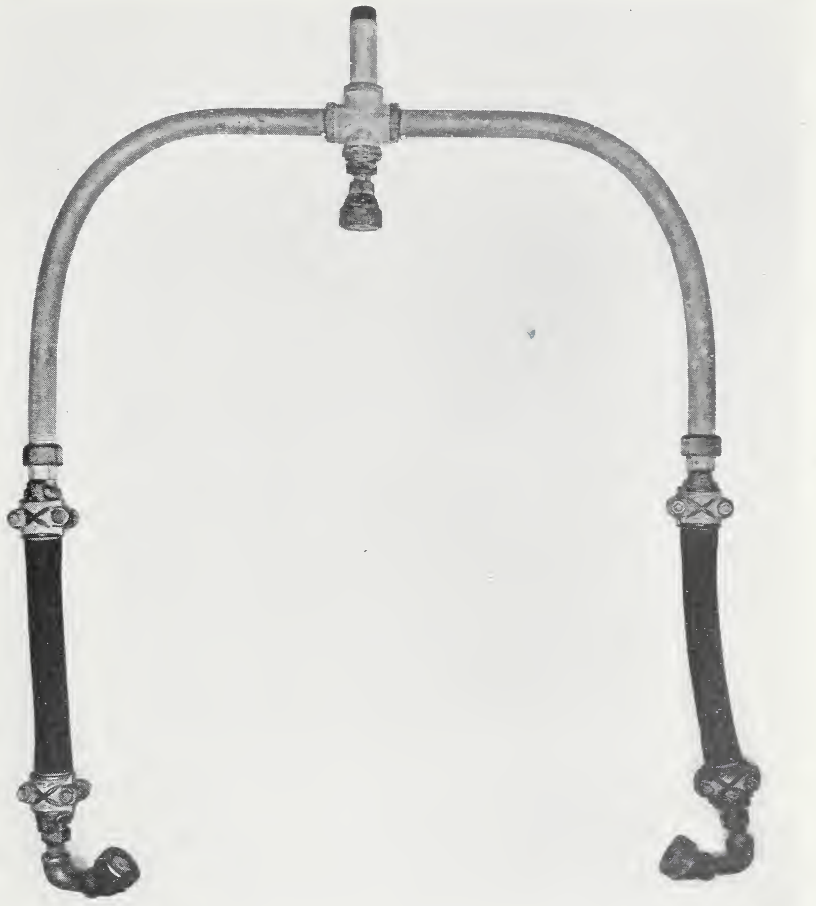

Figure 3.—Arrangement of nozzles used in spraying beans for the control of the Mexican bean beetle. The lower nozzles should be turned upward at an angle of 45° to assure effective coverage of the underside of the leaves.

The population counts on the treated and untreated plots were made beginning 10 to 14 days after the first spray application and were repeated three times at 14-day intervals, except in 1936, when they were repeated four times at 9- to 12-day intervals, and in 1935, when, because of insufficient time, no counts were made. These population records consisted of an actual count of the number of larvae, pupae, and beetles on three 50-foot-row samples selected at random in each plot. The four outside rows on each side of the plots and the extreme ends of the rows were eliminated from the area sampled in order to exclude any possible border effect. The insects were found and counted by turning up the leaves on the plants. In the tables these population data have been averaged for all the samples taken in each plot, and then the four replications of each treatment were averaged and expressed in numbers of insects per 100 feet of row.

Since both larvae and beetles cause damage, they have been considered together. Pupae also were counted, since they may be expected to cause damage as soon as pupation is ended.

After the crops were mature, samples from each of the treated and untreated plots were harvested, cured, and threshed. The samples threshed consisted of the plants from four entire rows selected near the center of each plot. The threshing was done in a small bean thresher which threshed from 12 to 20 bushels per hour and was believed to give more accurate results on small samples than larger threshers since it could be cleaned with less difficulty after each of the lots was threshed. Weights of the samples of threshed beans were taken and from these records yields per acre of each of the plots were calculated. The difference in yields between treated and check plots was calculated, as well as the monetary value of this difference after the cost of the treatment had been deducted. The value of the crop was based on market price at the time of harvest each year. These prices varied slightly from year to year. In 1935 the price per hundred pounds was \$3; in 1936, \$4.40; in 1937, \$4; and in 1938, \$3.25.

The cost of insecticides varied considerably from season to season. Derris of 4 percent rotenone content ranged in price from 21 to 42 cents per pound; cube of 4 percent rotenone content, from 17 to 38 cents; cryolite, from 11½ to 17 cents; zinc arsenite, from 11¼ to 12¼ cents; calcium arsenate, from 8 to 10½ cents; barium fluosilicate, from 13 to 19 cents; and magnesium arsenate was 24 cents per pound in the only year it was used.

The cost of applying the materials was calculated at 31 cents per acre per application, taking into consideration depreciations on the machinery, interest on the investment, and labor at 25 cents per hour.

CONTROL EXPERIMENTS IN 1935

As the project was begun too late in 1935 for data to be obtained on the emergence of overwintered beetles, the first applications were made when infestations were found high enough to require control measures.

Table 2 shows the insecticide used, the average yield on four replicates of treated and check plots, the crop increase on the treated plots, the cost of treatment, and the net financial returns.

TABLE 2.—*Results of experiments for the control of the Mexican bean beetle on irrigated fields at Grand Junction, Colo., 1935–38*

EXPERIMENTS OF 1935

Spray material	Average number of all stages per 100 feet of row		Control [1]	Average yield per acre		Crop increase per acre	Value of crop increase per acre	Cost of treatment per acre	Net returns per acre
	Treated plot	Check plot		Treated plot	Check plot				
	Number	*Number*	*Percent*	*Pounds*	*Pounds*	*Pounds*	*Dollars*	*Dollars*	*Dollars*
Derris (0.025 percent rotenone)	--------	--------	--------	1,341	1,119	222	6.66	3.74	2.92
Derris (0.015 percent rotenone)	--------	--------	--------	1,438	1,137	301	9.03	2.44	6.59
Cube (0.025 percent rotenone)	--------	--------	--------	1,284	1,062	222	6.66	3.52	3.14
Cryolite, 3 pounds to 50 gallons of water	--------	--------	--------	1,535	1,070	465	13.95	2.33	11.62

TABLE 2.—*Results of experiments for the control of the Mexican bean beetle on irrigated fields at Grand Junction, Colo., 1935–38*—Continued

EXPERIMENTS OF 1935—continued

Spray material	Average number of all stages per 100 feet of row		Control[1]	Average yield per acre		Crop increase per acre	Value of crop increase per acre	Cost of treatment per acre	Net returns per acre
	Treated plot	Check plot		Treated plot	Check plot				
	Number	*Number*	*Percent*	*Pounds*	*Pounds*	*Pounds*	*Dollars*	*Dollars*	*Dollars*
Zinc arsenite, 1½ pounds to 50 gallons of water				1,370	1,026	344	10.32	1.18	9.14
Calcium arsenate, 1 pound, and lime, 6 pounds, to 50 gallons of water				1,331	1,065	266	7.98	1.24	6.74
Magnesium arsenate, 1 pound to 50 gallons of water				1,123	1,026	97	2.91	2.22	.69
Barium fluosilicate, 3 pounds to 50 gallons of water				1,286	1,088	198	5.94	2.60	3.34
EXPERIMENTS OF 1936									
Derris (0.02 percent rotenone)	129	679	81	1,580	1,414	166	7.30	3.42	3.88
Derris (0.015 percent rotenone)	58	679	91	1,806	1,414	392	17.25	2.88	14.37
Cube (0.02 percent rotenone)	34	585	94	1,970	1,580	390	17.16	3.85	13.31
Cryolite, 3 pounds to 50 gallons of water[2]	116	674	83	1,933	1,527	406	17.86	2.68	15.18
Zinc arsenite, 1 pound to 50 gallons of water[2]	47	379	88	1,760	1,551	209	9.18	1.29	7.89
Calcium arsenate, 1 pound, and lime, 6 pounds, to 50 gallons of water[2]	69	379	82	1,755	1,564	191	8.40	1.91	6.49
Barium fluosilicate, 3 pounds to 50 gallons of water[2]	239	618	61	1,594	1,578	16	.70	2.75	−2.05
EXPERIMENTS OF 1937									
Derris (0.02 percent rotenone)	46	268	83	2,335	1,888	447	17.88	1.25	16.63
Derris (0.015 percent rotenone)	40	268	85	2,418	1,888	530	21.20	1.21	19.99
Cube (0.02 percent rotenone)	4	268	99	2,456	1,888	568	22.72	1.50	21.22
Cryolite, 3 pounds, to 50 gallons of water	51	253	80	2,263	2,016	247	9.88	1.26	8.62
Zinc arsenite, 1 pound to 50 gallons of water	16	253	94	2,205	2,016	189	7.56	.70	6.86
Calcium arsenate, 1 pound, and lime, 6 pounds, to 50 gallons of water	28	253	89	2,127	2,016	111	4.44	.93	3.51
Barium fluosilicate, 3 pounds to 50 gallons of water	115	253	55	1,924	2,016	−92	−3.68	1.40	−5.08
EXPERIMENTS OF 1938									
Derris (0.02 percent rotenone)	54	351	85	2,085	1,330	755	24.54	1.70	22.84
Derris (0.015 percent rotenone)	77	351	78	1,845	1,330	515	16.74	1.47	15.27
Cube (0.02 percent rotenone)	56	351	84	2,000	1,330	670	21.78	1.54	20.25
Cryolite, 3 pounds to 50 gallons of water	56	351	84	2,150	1,335	815	26.49	1.78	24.71
Zinc arsenite, 1 pound to 50 gallons of water	11	351	97	2,030	1,335	695	22.59	.88	21.71
Calcium arsenate, 1 pound, and lime, 6 pounds, to 50 gallons of water	66	351	81	1,815	1,335	480	15.60	1.18	14.42

[1] Obtained by dividing the difference between check and treated plots by the number on the check plot.
[2] Only 3 replicates of these plots.

On an average, the cryolite treatment gave the greatest increase in yield and financial return, and zinc arsenite gave the next best results. Among the rotenone sprays derris containing 0.015 percent of rotenone proved as effective as either derris or cube containing 0.025 percent of rotenone. There was no evident difference between derris and cube as a source of rotenone. The calcium arsenate and lime treatment gave as good results as derris, but was somewhat less effective than cryolite or zinc arsenite. Barium fluosilicate gave fair results, but magnesium arsenate was by far the least effective of all the materials tested.

Control Experiments In 1936

In 1936 the emergence of overwintered beetles from hibernation was complete on July 2. Spray applications on two of the four series of plots were made on July 2 and repeated on July 18. On the other two series, where the crop was planted later and the infestation of overwintered beetles developed somewhat later, the first spray application was made on July 15 and the second on August 7.

The average of 3 population counts of beetles, larvae, and pupae on 100 feet of row on 4 replicate plots, the percent reduction in numbers, the yield of treated and check plots, the increase in yield, the value of the increased yield, the cost of treatment, and the net returns are given in table 2.

Again, as in the experiments of 1935, the cryolite plots showed the greatest increase in yield, but the percentage reduction of population based on the counts was slightly less than for zinc arsenite. This indicates that zinc arsenite, while giving a good kill of insects, has an injurious effect on the plants. Howard [4] found in the Southeastern States that zinc arsenite had a noticeable injurious effect on the foliage. Derris and cube gave excellent control and a high increased yield. Derris containing 0.015 percent of rotenone was as effective as derris or cube containing 0.02 percent of rotenone. Calcium arsenate gave a good percentage of control, and the plots showed a fair increased yield and a net financial return. Barium fluosilicate, which gave a 61-percent reduction of population, showed a net financial loss of $2.05 per acre.

Control Experiments in 1937

The emergence of overwintered beetles from hibernation in 1937 was very light and was complete on June 27. Owing to the light emergence and to the fact that damaging infestations might not occur, spray applications were delayed as late as possible. Only one application was necessary, and this was made on July 14 to 19. One series of plots were on beans that were planted about 1 month ahead of the normal planting time. These plots had the heaviest infestations. The data from these experiments are given in the third block of table 2.

Based on the percent control as determined from population counts, all the materials tested gave excellent results with the exception of barium fluosilicate. The materials containing rotenone gave the greatest increase in yield by a considerable margin. Cryolite showed a greater increase in yield than zinc arsenite, which, however, gave the

---

[4] Howard, Neale F. the mexican bean beetle in the east. U. S. Dept. Agr. Farmers' Bul. 1407, 14 pp., illus. 1924.

higher percentage of control. The calcium arsenate plots gave only 111 pounds per acre increased yield, yet 89 percent reduction of population was recorded on these plots.

Control Experiments in 1938

The emergence of overwintered beetles from hibernation in 1938 was complete on July 2. At the beginning of the control experiments moderate infestations existed. They were somewhat lighter than in 1936 but heavier than in 1937. The first spray applications were made on July 6 to 8. On one series of plots, where heavier infestations occurred, a second application was necessary. This was made on July 27.

Table 2 also shows the data for this year's experiments.

Excellent control was obtained with all materials tested in 1938. Zinc arsenite gave the highest percentage of control based on population counts but, again as in 1936 and 1937, cryolite gave a higher yield, which indicated again that zinc arsenite has an injurious effect on the foliage. This season derris containing 0.015 percent of rotenone was slightly less effective, both in percentage control and in increased yield, than derris or cube containing 0.02 percent of rotenone.

DISCUSSION OF RESULTS

Based on the percentage control given by the derris spray containing 0.02 percent of rotenone, consistent results were obtained, ranging from 81 to 85 percent reduction of beetle population in the 3 years from 1936 to 1938. With derris spray containing 0.015 percent of rotenone, control ranged from 78 to 91 percent and averaged slightly above that given by the stronger concentration. This difference is probably not significant except to indicate that there is no advantage in using the stronger and more expensive mixture. Cube spray containing 0.02 percent of rotenone gave control ranging from 84 to 99 percent with an average slightly above that of the derris sprays. The cryolite sprays gave control ranging from 80 to 84 percent, which averages under the rotenone-bearing materials, but as the cryolite was cheaper, the net returns were usually greater. Zinc arsenite sprays gave results ranging from 88 to 97 percent, which is better control than that of the cryolite and comparable with that of the rotenone sprays. Calcium arsenate sprays gave results ranging from 81 to 89 percent control, which is lower than that by zinc arsenite or cube but comparable with that by cryolite, but it is necessary to use lime with this material to prevent injury to the foliage. Barium fluosilicate sprays gave only 61 and 55 percent control in 1936 and 1937, respectively, and this material was not used in 1938.

Results of these experiments expressed in terms of increased yield and net financial gain take into consideration the cost of the materials and their application as well as efficiency of the materials as insecticides. In the 4-year average there was no great difference in increased yield or financial gain between the rotenone materials. The weaker dilution of derris (containing 0.015 percent of rotenone) was about as effective as the stronger dilution of either derris or cube (containing 0.02 or 0.025 percent of rotenone). Except in 1937, the plots on which cryolite was used showed a greater increase in yield and financial gain per acre than those for the other materials tested Zinc arsenite spray showed lower increased yield and financial return than cryolite or the rotenone materials, which is not consistent with the greater reduction in beetle population, and would indicate that zinc arsenite has an injurious effect on the foliage. The calcium arsenate plots did not give so great an increased yield or financial gain as did the plots on which zinc arsenate, cryolite, or the materials containing rotenone were used. The relative records on reduction of population would indicate that calcium arsenate may also have some injurious effect on the foliage. Magnesium arsenate spray, tested only in 1935, was not effective enough to warrant its use in the following seasons.

Barium fluosilicate was found ineffective as a control for the Mexican bean beetle. In 2 of the 3 years it was tested there was a financial loss from its application.

The cost of treating an acre of beans varied considerably with the materials used, the number of applications required, and labor costs, and ranged from 70 cents to $3.85.

SUMMARY AND RECOMMENDATIONS

Experiments on control of the Mexican bean beetle on beans grown for the dry-bean market on irrigated land were conducted at Grand Junction, Colo., during the years 1935 to 1938, inclusive.

Sprays on a large-field-plot basis were applied with field equipment. The plots were approximately of 1 acre, and four replicates were used each season. Results were determined in terms of percentage control, and also by difference in yield and net returns between treated and check plots.

The first spray applications were made after emergence from hibernation of overwintered beetles was complete and before many eggs had been laid. In the Grand Junction area emergence was complete the first week in July. The first spray at this time will kill the overwintered beetles and thus stop egg deposition. Also, larvae hatching from eggs already deposited will feed for a few days on the leaf on which they hatch and not on new foliage developed after the spray application. If the spray is applied before all the beetles enter the field, new foliage will be available for the late-comers to feed on within a few days after the application. If there are fewer beetles than 5 per 50 feet of row, the first spray application may be delayed a few days.

Derris or cube containing 0.02 percent of rotenone and derris containing 0.015 percent of rotenone gave satisfactory control of the Mexican bean beetle (78 to 99 percent), and gave good financial gains. During the present war emergency, however, it is suggested that whenever possible, the other materials recommended in this circular be substituted for rotenone.

On account of cost, derris and cube may not be used so much on the dry-bean crop as cryolite and zinc arsenite.

Zinc arsenite spray gave good results in control but showed a financial gain slightly less than that shown by the rotenone-containing materials or cryolite, and this suggests the possibility of some foliage injury, as has been found by other workers.

Calcium arsenate spray gave a control of from 81 to 89 percent, but the financial gains on these plots averaged about one-half of that of cryolite and the rotenone materials.

Magnesium arsenate and barium fluosilicate are not to be recommended for control of the Mexican bean beetle on crops grown for dry beans in the West.

Power sprayers giving at least 150 pounds' pressure should be used. The spray nozzles should be so arranged that all parts of the plants, particularly the underside of the leaves, will be covered with the spray.

The cost of spraying in the experiments ranged from 70 cents to $3.85 per acre, depending on the material used, the number of applications required, and the cost of labor.

APPENDIX

The control experiments discussed in the preceding sections of this circular deal with the use of sprays against the Mexican bean beetle on the dry bean crop. In order to provide helpful information concerning the use of dust mixtures against this insect on the dry bean crop, and on the use of sprays and dusts on garden or canning beans, short discussions on these subjects are included as an appendix. This information has been taken principally from the results obtained and reported upon by workers of this Bureau in the eastern part of the United States.

Control of the Mexican Bean Beetle by Insecticidal Dusts

In 1938, dust mixtures containing 0.5 percent and 0.75 percent of rotenone were tested in four replicates in an experiment similar to those on sprays. Both talc and sulfur were tested as diluents. The control ranged from 78 to 98 percent, and the increases in yield ranged from 375 to 723 pounds per acre, showing that satisfactory control can be obtained in irrigated fields with dust mixtures containing rotenone. This single experiment, however, was not adequate to test the differences between diluents and between strengths of rotenone, and therefore the detailed data are not presented.

Howard, Brannon, and Mason,[5] working in the eastern part of the United States, make the following recommendations in regard to the use of dust insecticides for control of the Mexican bean beetle:

> Derris or cube dusts of a rotenone content of 0.5 percent, either commercial or home-mixed, may be used when applied at the rate of 20 to 25 pounds to the acre per application. In the case of home-mixed dusts, either talc, dusting sulfur, infusorial earth, pyrophyllite, or other finely ground inert clay, gypsum, diatomaceous earth, wheat flour, or tobacco dust may be used as a diluent or carrier, but recent experiments have indicated that talc is the most satisfactory. Dusting machines vary in their suitability for use with different materials. A grower may use the one of the carriers or diluents mentioned which is best suited to his machinery and most readily available to him at a reasonable price * * *.

Control on Garden or Canning Beans

The spray materials which are used in the large field plots may also be used on beans grown for canning or in the garden, but **caution**

---

[5] Howard, N. F., Brannon, L. W., and Mason, H. C. THE MEXICAN BEAN BEETLE IN THE EAST AND ITS CONTROL. U. S. Dept. Agr. Farmers' Bul. 1624, 21 pp., illus. (Revised 1943.)

must be exercised not to use cryolite or any arsenical after the pods begin to form if the crop is grown for consumption as green beans. Howard, Brannon, and Mason[6] give the following recommendation for the control of beetles in localities where the crop is marketed or used green:

> Derris or cube powder having a rotenone content of 4 percent should be used at the strength of 1½ pounds to 50 gallons of water. Derris or cube powder of a different rotenone content should be used in proportion to that content so as to make a spray containing 0.015 percent of rotenone. Cryolite should be used in the proportion of 4 pounds in 50 gallons of water.
>
> The spraying must be done so thoroughly that the undersides of the leaves on all the plants are reached by the spray.
>
> Begin spraying when the adults are found in the field or when the eggs of the beetle become numerous on the undersides of the leaves.
>
> One to three, sometimes four, applications are required, depending on the abundance of the insect.
>
> As important as thorough spraying is the destruction of the crop remains after the harvest. Plow under all plant remnants at least 6 inches deep.
>
> Dusting as a rule does not give as good results as spraying. A dust containing derris or cube (4-percent rotenone) 12½ pounds, and talc, sulphur, clay or other diluent, 87½ pounds, may be used.
>
> **Cryolite or any arsenical should not be applied to beans after the pods begin to form.**

---

[6] See footnote 5, p. 11.

U. S. GOVERNMENT PRINTING OFFICE: 1944